

CONTROL OF OXYGENATION

5 **Field of the Invention**

This invention relates to the control of oxygenation of stored liquids. It relates particularly but not exclusively to methods and apparatus for the control of oxygenation of wine.

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Background of the Invention

Many red and some white wine varieties are matured in oak barrels, according to the wine variety, quality and desired character.

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The general aim of wine aging in Oak barrels, is to develop a desired aged wine bouquet and character, by:

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- Controlled and slow oxidation of various wine substances especially the phenolic compounds. This slow oxidation, followed by polymerization, results from limited and gradual exposure to air oxygen diffusing through the walls of the barrel over months.

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- Extraction of Oak flavour components, including Oak phenolics to enhance and expand the wine's complexity.

However Oak barrels are expensive to fashion, cumbersome to store and handle, often inconsistent in wood properties, subject to leakage and limited in useful life.

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Oak barrels also require a voluminous storage facility with a controlled temperature and humidity environment to minimize evaporative loss due to transpiration through their porous walls.

Accordingly there have been many attempts to replicate the effects of barrel aging on wine, without the actual use of oak barrels. For example:

- 5 - The addition of Oak sawdust, chips or staves into metal bulk storage tanks, to expose the wine to Oak characters. However this only achieves the Oak flavour extraction function of barrel aging, not the oxidative one. This can be mitigated to some extent by regularly "pumping over" the wine in the tank, in order to re-aerate it. However this often introduces too
10 much dissolved oxygen all at once, allowing aerobic bacteria such as Acetobacter to become established and begin oxidizing the ethanol in the wine into acetaldehyde, ethyl acetate and ultimately acetic acid, with consequent loss of wine quality. These oxidation products are termed "volatile acidity" in the wine industry.
- 15 - The development of composite containers made of metal (stainless steel) and fitted with flat Oak panels or ends which can be more easily fashioned and which may be reversed to expose fresh Oak to the wine contents. Such containers usually don't have the optimum ratio of surface area of
20 Oak to volume of wine contained and are usually inadequate both in the extractive and oxidative functions.

More recent developments include the use of "micro-oxygenation" wherein air or pure oxygen is introduced directly into bulk-tanked wine with added Oak chips or
25 planks, by generating very fine bubbles through the wine by means of a micro-porous (ie. sintered) dispersion element on the end of a submerged gas line or lines.

This is a difficult process to adequately control and can possibly lead to excess levels of dissolved oxygen at the bubble interfaces, again promoting ethanol oxidation and
30 other degradative side-effects through fast oxidation of wine. The equipment required to contain and feed fixed volumes of oxygen or to accurately meter a continuous flow over set time periods at very low flow rates, is normally expensive and difficult to operate. That cost also means the resource has to be shared over a

number of tanks, which militates against long, slow maturation times in individual tanks.

Recent studies such as reported in "Gaseous Exchange in Wine Stored in Barrels",
5 Moutounet, Mazauric et al, J. Sci. Tech. Tonnellerie, 1998 (herein incorporated by
reference) have explained the mechanism by which barrels add oxygen to wine and
promote "correct" maturation. The oak walls of wine barrels act as semi-permeable
"membranes", allowing oxygen gas in the atmosphere outside the barrel to permeate
10 through the barrel walls and diffuse into the wine. This osmotic exchange is driven
by the partial pressure difference of the atmospheric oxygen outside the barrel (0.18
atm) and the effectively zero partial pressure of oxygen inside. This absence of
oxygen in the barrel arises because wine continuously consumes all available oxygen
in the slow-oxidation reactions that occur in the reductive environment that exists
when the rate of oxygen addition occurs at very low rates over long periods, due to
15 slow diffusion.

Furthermore, it has been shown that it is this slow permeation (diffusion) of
atmospheric oxygen that contributes most to "barrel softening or maturation".
Moutounet et. al. (referred to above) showed that a typical new oak barrique allows
20 O₂ permeation through its walls, in the range of 20-30mg/l.yr. Kelly and Wollan
report an estimated "highest diffusion" (ie. permeation) rate into a typical barrique
as 2.2ml O₂/litre wine/month or 26.4 ml/l/yr (34.6mg/l./gr) in their paper "Micro-
oxygenation of Wine in Barrels", Wine Network Technology, www.winenet.com.au,
incorporating International Patent Application PCT/AU02/01250 (both herein
25 incorporated by reference).

Any free surface arising from head-space in a wine storage vessel is undesirable, if it
contains oxygen. At that surface the levels of dissolved oxygen increase in
concentration, to near saturated (9 ppm at 20 Celsius and 1 atm). In this oxygen rich
30 surface layer aerobic bacteria will propagate, generating volatile acidity and
acetaldehyde at a rate dependent usually on the surface area of the free surface and
the oxygen content of the surface gas. The lesser the free surface area, the longer that
wine can be safely kept in bulk storage.

Disclosure of the Invention

- The invention provides in one aspect a method of controlling rate of oxygen transfer
5 from the atmosphere into a liquid comprising,
storing the liquid in a closed container having walls exposed to the
atmosphere at atmospheric pressure,
wherein the container is self supporting and the walls of the container
comprise a rigid plastics material which allows oxygen (typically at atmospheric
10 partial pressure of 0.18 atm) to permeate the walls directly from the atmosphere into
the liquid in contact with the walls at a rate of 13mg to 65mg of oxygen per square
metre of the wall area for each 1 millimetre of the walls thickness per 24 hour period
at room temperature.
- 15 Suitably, the liquid comprises wine.

- In order to limit the transfer of oxygen into the surface of the wine, a barrier member
may be floated on the surface. Suitably, the barrier member has a peripheral portion
which is in sliding contact with the container walls to separate the liquid surface from
20 the head space in the container.

- Typically, the wine may be stored in the container for a period ranging between 4
months and 36 months with the total rate of oxygen transmission into the wine being
maintained at less than 55mg/litre of wine/year.

- 25 Oak staves may optionally be suspended in the wine during the storage period.

- In another aspect, the invention provides a container assembly for controlling rate of
oxygen transfer from the atmosphere into a liquid stored in the container assembly
30 comprising,

a container with an oxygen permeability of 13mg to 65mg of atmospheric
oxygen per square metre of area of walls of the container for each millimeter of the
thickness of the walls per 24 hour period at room temperature, and

a barrier member for providing a barrier to limit oxygen access from head space in the container to a surface of the liquid the barrier member having a construction which causes it to float on the liquid surface.

5 A peripheral flange may surround the barrier member so that it makes slidable contact with the walls of the container.

In another aspect the invention provides a barrier member as described herein.

10 The method and apparatus of the invention can achieve the simultaneous extractive and slow-oxidative effects of Oak barrel aging without the need to use such barrels or to add extra oxygen gas or air into the wine.

15 Furthermore the method of our invention allows the independent adjustment of both the degree of Oak extraction and the degree of slow-oxidation. In this way it is possible to replicate the different extractive and oxidative effects of Oak casks of different ages (the oxygen permeability of a barrel decreases by about 20% for each year it is used) and of different surface area to volume ratios. Common Oak cask sizes are Barriques (225 litres), Hogsheads (300 litres) and Puncheons (500 litres).

20 Preferred aspects of the invention will now be described with reference with to the accompanying drawings.

Brief Description of the Drawings

25 Figure 1 shows a cut away isometric view of a wine container constructed in accordance with the invention;

Figure 2 shows an enlarged view of the circled area at the top of Figure 1;

Figure 3 shows an enlarged view of the circled area shown at the bottom of Figure 1;

30 Figure 4 shows an alternative tank construction;

Figure 5 shows an enlarged cross sectional view of part of the circled region of Figure 4; and

Figure 6 shows an isometric view of a barrier member for use with the invention.

Detailed Description of the Preferred Embodiments

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The various elements identified by numerals in the drawings are listed in the following integer list.

Integer List

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	1	Cover
	2	Water trap
	3	Level
	4	Plastic tank
15	5	Staves
	6	Hole
	7	Rod
	8	Base valve
	9	Cylinder
20	10	Outer cylinder
	11	Disc
	12	Lip
	14	Top panel
	15	Skirt
25	20	Plastic tank
	21	Neck
	22	Closure
	23	Skirt
	24	Water trap
30	25	Circumferential wall
	26	Tap
	28	Wine
	30	Barrier member

- 31 Foamed plastic core
- 32 Polyurethane film overwrap
- 34 Peripheral flange
- 35 Wall
- 5 36 Tag
- 37 Hole/loop

Referring to Figures 1 to 3, there is shown an optionally thermally insulated plastic tank with an opening in the top defined by neck formed as a cylinder 9 forming part
10 of the tank, to which any closure can be fitted.

In this embodiment an optional circumferential wall in the form of an outer cylinder 10 is welded to or molded as part of the tank 4 and an optional base valve 8 is fitted through the side wall, above the base of the tank so as to enable bottom filling or
15 discharge of the tank contents without disturbing sediment that may have settled to the bottom of the tank.

The tank 4 is sealed by means of a closure comprising an inverted dome-shaped cover 1 having a top panel 14 and depending skirt 15. The skirt is partially submerged in a
20 water trap 2 formed by adding water to the space between the two concentric cylinders 9 and 10. Whilst the specific embodiment shown uses a water trap it is to be appreciated that a simple closure such as a wide mouth screw cap can be used. It is preferable that the closure and container neck be wide enough to allow a person to have hand access to all internal surfaces for cleaning.

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The tank 4 and top cylinders 9 and 10 are made from polyethylene with an oxygen permeability in the range between 13mg to 65mg of atmospheric oxygen per sqm of tank surface per 24hr for each 1mm of tank wall thickness at typical storage temperatures of 20-25 degr C.

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The ratio of contained volume to surface area of the container falls within the range 5 to 30 litres per square metre of surface for each 1mm of thickness, to ensure that an adequate rate of permeation of oxygen is maintained.

Suspended within the wine-filled tank are an optional number of oak-wood staves 5 of the desired variety and degree of toast (ie. charring). At the lower end of each stave a hole 6 is drilled to enable that stave to be threaded onto or otherwise attached to a solid rod 7 usually made of stainless steel, which is sufficiently heavy to keep all of the wooden staves attached to it from floating to the surface. The total surface area of oak-wood presented to the wine will depend on the variety of wine, the degree to which the winemaker wants to impart oak character to it and the number of times the oak staves have already been used in wine.

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In this embodiment, the stainless steel rod 7 is bent into a "U" shape, so that the ends hang downwards and the staves float upwards. By this simple means the staves are prevented from floating off the ends of the rod 7.

15 Alternatively, the oak planks may be pre-assembled into a pack, not requiring a hole or rod to fit them onto. The pack may be inserted preassembled through the mouth of the tank and removed for replacement, cleaning or sterilization as and when required.

The level of wine 3 in the tank will normally lie within the top cylindrical chamber formed by the cylinder 9. Resting or floating on the wine surface is a barrier member comprising a buoyant disc 11 made of wine-safe polymer such as polyethylene. It may comprise an upside down dish shape. Alternatively it may be a composite structure comprising a disc of plastic foam overwrapped and sealed within a wine-safe film of predetermined oxygen barrier properties. The outer perimeter of the buoyant disc may optionally be furnished with a flexible lip 12 which forms a "wiper seal" with the inner face of the chamber cylinder 9. ~~The purpose of the buoyant disc~~ is to lie in and block the free wine surface from access to the head space air or gas in the chamber 9. The disc minimizes the rate at which particular gases in the head space, such as oxygen, can dissolve into the wine via the free surface.

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The buoyant disc acts as a barrier member which can also have tailored gas permeability suitably at the levels already described to enable controlled oxygen permeation into a tank made from impermeable material, such as Stainless Steel.

Thus, the barrier member and poly tanks can be used together or separately, to passively "meter" the addition of atmospheric oxygen into wine, without allowing conditions to develop where a significant free surface area of wine is directly exposed to the atmosphere.

The upper limit of mass transfer of oxygen into wine by permeation is typically about 80mg/l/year. At rates higher than that wine is not capable of using up all the available oxygen in typical maturation reactions and a measurable concentration of dissolved oxygen results. In those conditions, aerobic bacteria such as acetobacter, and gluconobacter, which are always present in low populations in all wine that hasn't been sterile-filtered will propagate and damage the wine.

When used in the main body of a tank as is shown in Figure 4 CO₂ can be added into the head space to protect the small area of exposed wine around the perimeter of the added barrier member. As gas dissolves into liquid at a rate directly proportional to the exposed surface area, re-charging the head space with CO₂ only needs to be done very infrequently when a barrier member is used, ie. once per month rather than every couple of days, due to the 50 to 100 fold typical reduction in exposed surface area. The exposed annulus is typically about 5mm wide. If the tank body has a diameter of "D" in meters, the exposed surface without barrier = $\pi \times D^2/4$ and with a barrier it is $0.005 \times \pi \times D$. For a tank of 1m diameter, the exposed surface with a barrier is proportionally $0.005 \times 4/D$ or just 2% of that without a barrier member.

The edge flap helps to centralize the disc, keep out contamination and contain SO₂ gas that is coming out of solution from the wine so that mould cannot grow there.

Referring to Figures 4 to 6, there is shown a plastic tank 20 for wine with a neck construction generally designated 21. Whilst the illustrated tank is plastic it is to be appreciated that the tank may be made of any suitable wine contact material such as stainless steel and uses any typical closure that seals the opening.

A closure 22 having a depending circumferential skirt 23 closes off the neck.

As in the case of the previously described container, a circumferential wall 25 surrounds the neck and provides a water trap 24 between the neck and circumferential wall and the skirt 23 of the closure fits into this water trap to seal off the neck.

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A tap 26 is provided at the bottom of the container to drain off the wine 28 as and when needed.

10 A barrier member 30 having a foamed plastic core 31 floats on top of the wine in the body of the container. The foamed plastic core 31 of the barrier member is overwrapped with a polyurethane film overwrap 32 which comprises two separate layers covering the top and bottom of the foamed plastic core. These two separate layers are laminated together at their edges to form the peripheral flange 34. The peripheral flange provides a slidable seal with the wall 35 of the container so as to
15 substantially reduce the rate of oxygen transfer from the head space of the container through the surface of the wine and hence limits the growth of undesirable aerobic bacteria.

The barrier member is provided with three tags 36 distributed around its upper
20 surface, each of the tags being formed with a hole or loop 37. The tags assist with allowing the barrier member to be correctly located in the container in contact with the wine initially and to be removed after the container has been emptied. In this regard, it is noted that the barrier member comprising the foamed plastic core and polyurethane film overlap may suitably be formed of flexible materials in order to
25 allow it to be folded so that it may be inserted through the neck of the container during initial setup and ~~to be removed through the neck when the container is~~ emptied.

Whilst the above description includes the preferred embodiments of the invention, it
30 is to be understood that many variations, alterations, modifications and/or additions may be introduced into the constructions and arrangements of parts previously described without departing from the essential features or the spirit or ambit of the invention.

It will be also understood that where the word “comprise”, and variations such as “comprises” and “comprising”, are used in this specification, unless the context requires otherwise such use is intended to imply the inclusion of a stated feature or
5 features but is not to be taken as excluding the presence of other feature or features.

The reference to any prior art in this specification is not, and should not be taken as, an acknowledgment or any form of suggestion that such prior art forms part of the common general knowledge in Australia.